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UNITED STATES
ATOMIC ENERGY COMMISSION

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		3-27-50
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In Reply Refer To:
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Oak Ridge, Tennessee
March 22, 1950

Carbide and Carbon Chemicals Division
Union Carbide and Carbon Corporation
Post Office Box "P"
Oak Ridge, Tennessee

Attention: Dr. C. E. Larson, Director, Oak Ridge National Laboratory

Subject: METEOROLOGICAL DATA FOR REACTOR SAFEGUARD COMMITTEE

Gentlemen:

Transmitted herewith are 10 copies of "Winds in the Vicinity of X-10 correlated with Thermal Stability and Precipitation" prepared by the Weather Bureau group here. The material contained in this report was prepared at the request of Mr. W. H. Ray, then of the ORNL Health Physics Division, in a telephone call to J. Z. Holland, Weather Bureau meteorologist assigned to this office, on February 15, 1950, and is specifically designed to satisfy the requirements contained in the "Summary Report of the Reactor Safeguard Committee".

Sincerey yours,

Albert H. Holland, Jr., M. D.
Director of Research and Medicine

10 Enclosures:
As stated above.

CC: Mr. C. E. Center, C&CCD
Mr. R. W. Cook, AEC

WINDS IN THE VICINTY OF X-10 CORRELATED
WITH THERMAL STABILITY AND PRECIPITATION

U. S. Weather Bureau
Oak Ridge, Tennessee
March 21, 1950

1. <u>Winds at the 140-foot water tower in relation to stability.</u>

Table 1 shows the average annual frequency of wind direction to eight points at the wind instruments on the 140-foot water tower operated by ORNL Health Physics Division at X-10, for the period January 1944 through February 1950. Frequency distributions are given for all hours with zero or positive temperature gradient from the 4-foot to the 183-foot level on the X-10 water tower ("Inversion"), all hours with negative temperature gradients ("Lapse"), and all hours combined. Figures 1, 2 and 3 show the data in wind-rose form.

TABLE 1

Wind Direction Frequency (%)

	Inversion	Lapse	Total
NE	28.2	21.6	25.0
E	9.8	8.1	9.0
SE	3.6	5.2	4.4
S	7.0	5.5	6.3
SW	21.1	30.2	25.4
W	16.2	15.5	15.9
NW	5.1	8.8	6.9
N	6.4	4.2	5.3
Calm	1.6	0.3	1.0
Indeterminate	1.0	0.6	0.8

The prevailing wind direction is west-southwesterly, with a secondary maximum frequency from the east-northeast. These appear as large percentages of west, southwest, east and northeast in the eight-point rose, and reflect the orientation of the broad valley between the Cumberland Plateau and the Great Smoky Mountains on a large scale, and on a smaller scale, of Bethel Valley (which contains the X-10 site), and the adjoining ridges. The WSW wind is the up-slope wind, the ENE wind down-slope, in relation to the larger valley. Over a period of approximately 6 years, the X-10 wind direction instrument has recorded W or SW 41% of the time, and E or NE 34%, with only 23% from the remaining 180° of the compass. During inversions (zero or positive vertical temperature gradient in the

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lowest 180 feet) the E and NE winds show a slight predominance, occurring 38% of the time as compared with 37% from W and SW. On the other hand, in lapse conditions (negative vertical temperature gradient in the lowest 180 feet) W and SW occur 46% of the time as compared with only 30% from E and NE. The west-southwesterlies are also the predominant winds of spring and early summer, and of the afternoon hours, while the east-northeasterlies prevail in late summer and fall, as well as during the night and early morning hours. In winter this local circulation is overshadowed by the frequent west winds associated with moving weather systems. Thus, in general, the westerly and southwesterly winds are the more turbulent winds and the northeasterlies the more stable winds.

The annual average speed of the wind at the 140 foot tower is 5.7 mph, varying seasonally from about 4 mph in summer to about 7 mph in winter. Calms occur only 1% of the time at this height, the frequency being greatest (1.6%)during inversions and least (0.3%) during lapse. Maximum speeds occur during the afternoon hours, with the lowest average speed and greatest frequency of calms occurring at night.

2. Frequency of inversions

Inversions as defined in the first paragraph occur about 52% of the time annually. The monthly and annual frequencies for the period of record are shown in Table 2. It can be seen that while there are wide variations from year to year, the greatest monthly frequency tends to occur in October with an average of 61% and the least in June averaging 48%.

Table 2
Frequency of Inversions (%)

	1944	1945	1946	1947	1948	1949	1950	Average
January	42.5	42.5	59.0	53.1	64.4	18.4	61.5	48.8
February	25.1	30.2	61.5	M	69.0	50.7	62.1	49.8
March	45.5	44.9	61.5	M	61.0	61.9		55.0
April	40.9	43.2	58.3	M	55.5	52.1		50.0
May	49.9	46.0	46.5	M	48.3	62.6		50.8
June	42.4	47.9	48.3	39.7	49.7	56.9		47.5
July	48.4	50.6	49.3	51.8	41.8	61.2		50.5
August	41.5	59.0	53.7	67.0	31.8	53.1		51.0
September	49.6	62.1	57.4	51.4	33.4	62.6		52.8
October	60.4	60.2	67.1	77.6	30.7	71.2		61.2
November	43.2	74.3	42.5	57.1	36.0	70.0		53.9
December	62.6	56.6	38.8	75.8	31.8	62.2		54.6
Annual	46.0	51.5	53.7	59.2	46.1	56.9		52.2

M - Missing

This monthly distribution of stability and instability in the lowest 180 feet of the atmosphere is correlated with conditions in the deeper layers of the troposphere, as evidenced by the 79 years of standard weather observations at Knoxville, approximately 25 miles east of Oak Ridge. If the months are ranked from 1 to 12, in descending order, according to high frequency of clear skies, dense fog and low visibilities, low frequency of partly cloudy skies (indicative of turbulence) and thunderstorms, high daily temperature range and 1:30 p.m. relative humidity (both indicative of restricted vertical mixing) and low average wind speed, the sum of ranks should be a fair stability index. This type of analysis shows October, November and December to be the most stable (lowest total rank), July, June and March the most unstable months.

Furthermore, a high pressure center on the monthly mean sea level pressure charts, indicative of a tendency toward stability in the lower few thousands of feet, occurs in this portion of the country during October, November, December and January. Thus, although the total frequency of temperature inversions will become considerably less above 500 to 1000 feet due to the disappearance of the nocturnal radiation inversions, the seasonal variation will follow a similar pattern at the greater heights.

3. Local variations in the winds.

Considerable variation is observed in both wind speed and direction within small distances in the valley, as a result of variations in elevation, slope and vegetation cover. Instruments located in relatively sheltered places such as White Oak Creek Pass through Haw Ridge, the adjacent low areas of Bethel Valley, and areas covered with tall trees show, in the lowest 50 feet, 20 to 90% of calms at night (8 p.m. to 8 a.m.) and annual average speed of less than 3 mph. Well exposed valley locations (rises w ithin the valley, free of trees) have 10 to 20% of calms at night, few calms in the daytime, and average speeds in the neighborhood of 4 mph. Exposed hill-tops have very few calms at any time and average speeds of 4 to 8 mph, comparable to those observed on the water tower.

Up-slope wind directions prevail in the lowest 50 feet at points off the valley axis during daytime, lapse, and early summer, accompained by gustiness and moderate speeds. Light downslope movements prevail at night and in inversions. Bethel Valley and the adjoining ridges form the dominating configuration with respect to the air flow. Such secondary features as the White Oak drainage basin within Bethel Valley, the many ravines in the ridges, and even the White Oak Creek gap in Haw Ridge make a negligible contribution to the total transport of air. Although these features may produce pronouned local eddies, such effects do not extend far towards the center of the valley.

Within this surface layer, horizontal continuity of movement is poor, especially in cross-valley directions: each valley may develop an independent circulation, the major outlet being through exchange with the upper air via the slope winds and convective eddies. Only with strong winds or with prevailing upper winds (2000 to 5000 feet) parallel to the valleys would it be of value to extrapolate air movements for any number of miles using valley wind observations. An exception is the well developed inversion case where even a very light air movement will follow the valley as far downstream as the valley retains its structure even though the prevailing winds a few hundred feet above the ground may be in an entirely different direction. In general, air transport from a valley location will be governed by the valley wind regime combined with the mode and degree of exchange with the upper air, and the winds in the upper streams.

4. <u>Upper winds.</u>

Table 3 and Figures 4 and 5 show the frequency distribution of wind speed and direction to 16 points at 3000 and 10,000 feet above sea level at Knoxville, Tennessee based on 9162 pilot balloon observations at 3000 and 4919 observations at 10,000 feet. These wind roses represent all the observations prior to January 1, 1939, and are derived from the U. S. Weather Bureau Airway Meteorological Atlas for the United States.

Table 3
Frequency of Wind speed and direction (%)

	3000 feet above sea level				10,000 feet above sea level			
	Under 18 mph	18-31 mph	over 31 mph	Total	under 18 mph	18-31 mph	over 31 mph	Total
NNE	4	1	0	5	2	1	0	3
NE	4	1	0	5	1	1	0	2
ENE	4	2	0	6	1	1	0	2
E	2	1	0	3	1	0	0	1
ESE	1	0	0	1	1	0	0	1
SE	1	0	0	1	1	0	0	1
SSE	1	0	0	1	2	0	0	2
S	2	1	0	3	2	1	0	3
SSW	4	3	1	8	3	2	0	5
SW	6	8	3	17	4	3	1	8
WSW	7	6	1	14	4	4	3	11
W	6	4	1	11	5	7	6	18
WNW	4	2	0	6	4	7	6	17
NW	4	1	0	5	4	5	3	12
NNW	3	1	0	4	3	3	1	7
N	4	1	0	5	2	2	1	5
Calm				6				2
Total	57	32	6	101	40	38	21	100

Above the ridge tops, the winds follow closely the broad currents of the main valley between the Cumberlands and the Smokies. From the 3000 foot level (2000 feet above ground) there is, on the average, no significant difference between observations taken at Oak Ridge and those taken at Knoxville.

The northeast-southwest axis of the large valley continues to influence strongly the direction distribution up to about 5000 feet, the southwesterly winds increasing steadily in frequency at the expense of the northeasterly. Above 5000 feet the southwesterly winds give way to the prevailing westerlies observed generally at this latitude. At 2000 feet above the ground the 90° sector centered between southwest and west-southwest contains 50% of all observations. By 10,000 feet 58% of the observations show directions within the quadrant centered between west and west-northwest.

The greatest frequency of surface wind direction coinciding with or approximating the upper wind direction occurs in lapse conditions. In inversions the lower layers tend to move in a direction independent of the upper wind.

The average speeds increase from 1-4 mph within 50 feet of the valley floor (800 to 900 feet above sea level) to 6-8 mph at ridge top level (1100 to 1400 feet above sea level), then to about 15 mph at 3000 feet and 25 mph at 10,000 feet. The frequency of winds less than 4 mph correspondingly decreases from over 50% near the valley floor to about 30-40% at the highest anemometer stations, 6% at 3000 feet and 2% at 10,000 feet.

5. Correlation of wind direction with precipitation

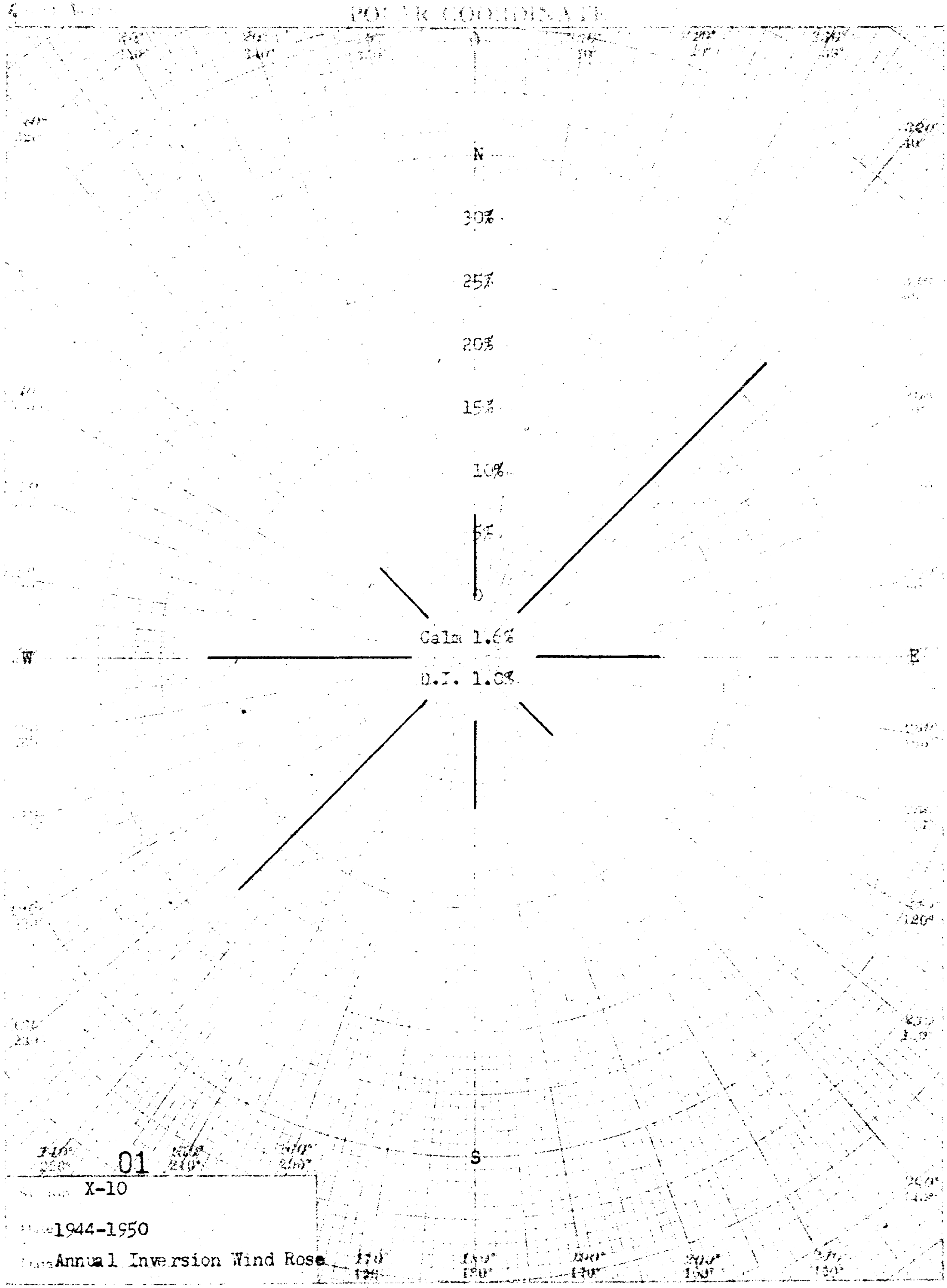
Table 4 and Figures 6 and 7 show the frequency distribution of gradient and 10,000 foot wind direction to eight points for times with rain at Oak Ridge. These wind directions were obtained from the isobars in the published U. S. Weather Bureau Daily Weather Maps for August, 1948 through February, 1950. The 10,000 foot wind directions are from the 700 mb contours at 10 a.m. on days during which rain was recorded. The gradient wind directions are from the sea-level weather maps with rain at the time of observation. These latter directions should compare well with the actual wind directions at 2000 to 4000 feet above sea level.

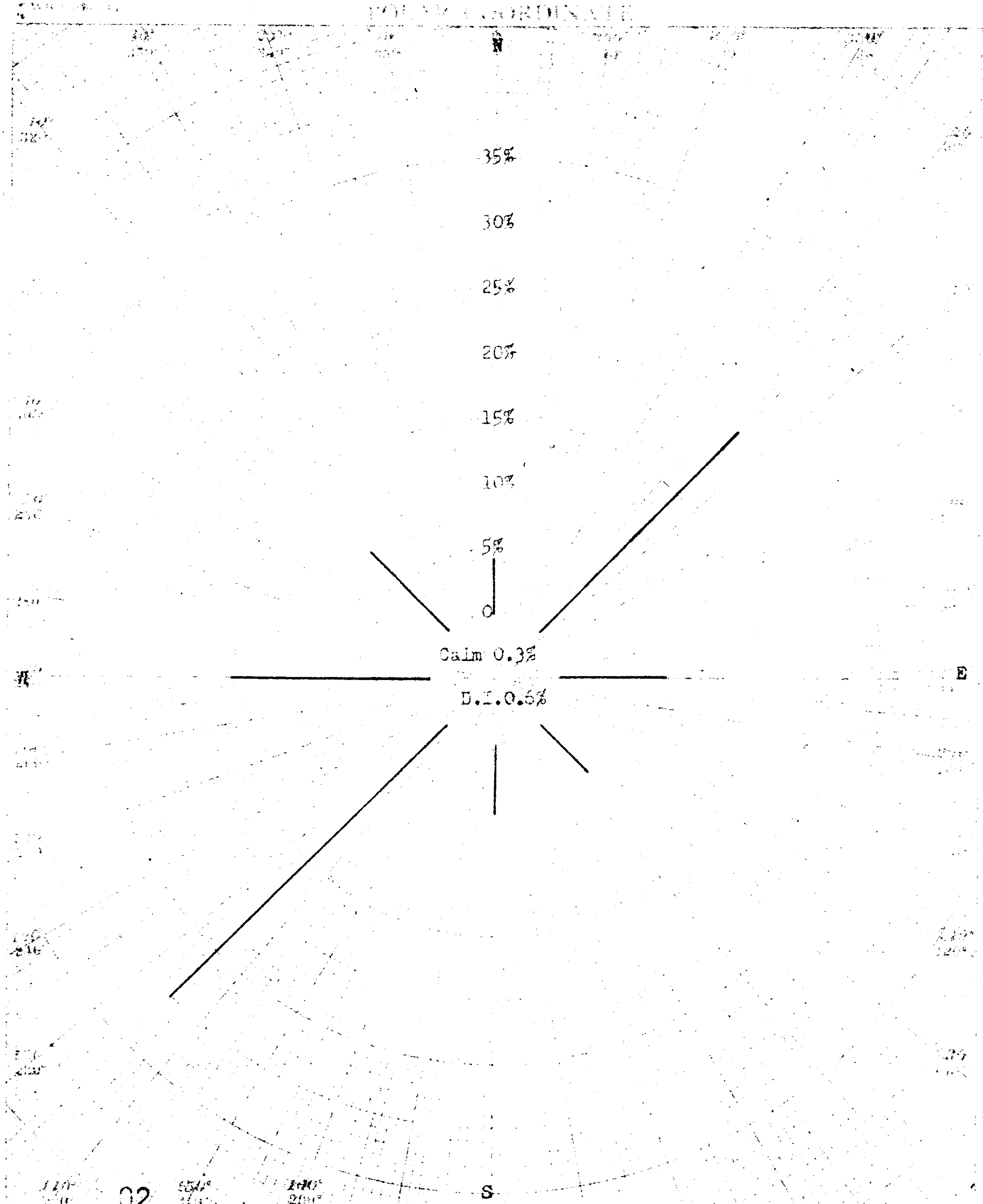
Table 4
Wind direction frequency with rain (%)

	Gradient		10,000 feet	
100% =	Rain Obs.	All Obs.	Rain Obs.	All Obs.
NE	10.8	3.6	0	0
E	3.6	1.2	1.1	0.5
SE	9.2	3.0	5.0	2.3
S	20.9	6.8	6.5	3.1
SW	25.2	7.9	45.2	21.4
W	8.4	2.7	29.8	14.2
NW	9.3	3.1	10.7	5.1
N	10.7	3.6	1.5	0.7
Calm	1.9	0.6	0	0
Total	100.0	32.5	99.8	47.3

It is seen by comparison of Figs. 6 and 7 with Figs. 4 and 5 that the rain wind rose resembles the average pilot balloon wind rose for the corresponding level shifted approximately 45° to the south. The gradient level now shows 46% of south and southwest combined, and the 10,000 foot level 75% of southwest and west.

The annual number of days with .01 inches or more of precipitation, based on 79 years of record at Knoxville is 134. The greatest frequency, 13 days per month, occurs in January and March, the least 7 to 9 in fall. In the short period of record at X-10, it appears that the precipitation frequency may be slightly higher than that at Knoxville, but the difference is not significant by comparison with the variations between different years at the same station.


N
30%
25%
20%
15%
10%
5%
0
Calm 1.6%
D.I. 1.0%
W
E
S
01
X-10
1944-1950
Annual Inversion Wind Rose

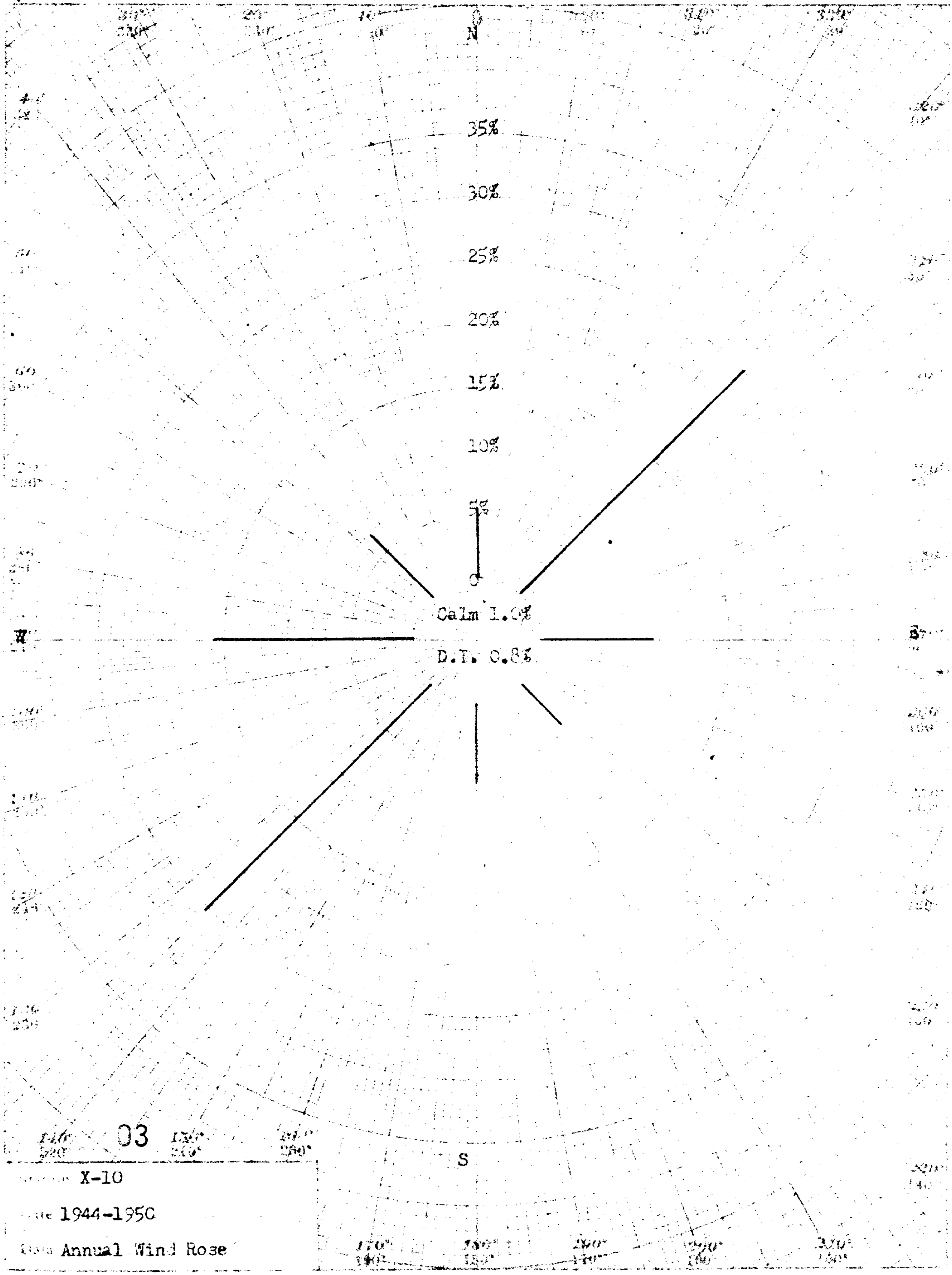


02

X-10

1944-1950

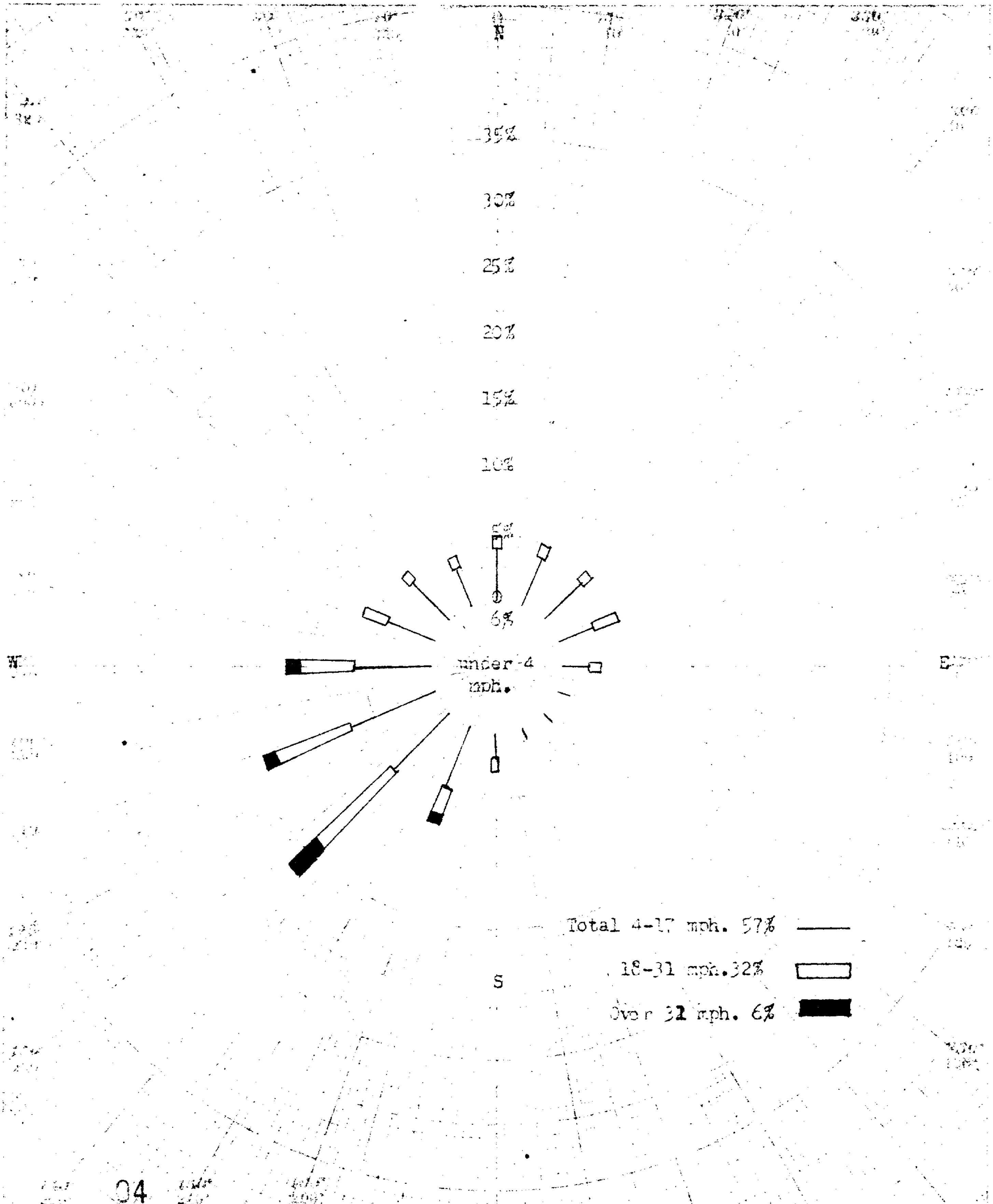
Annual Lapse Wind Rose



X-10

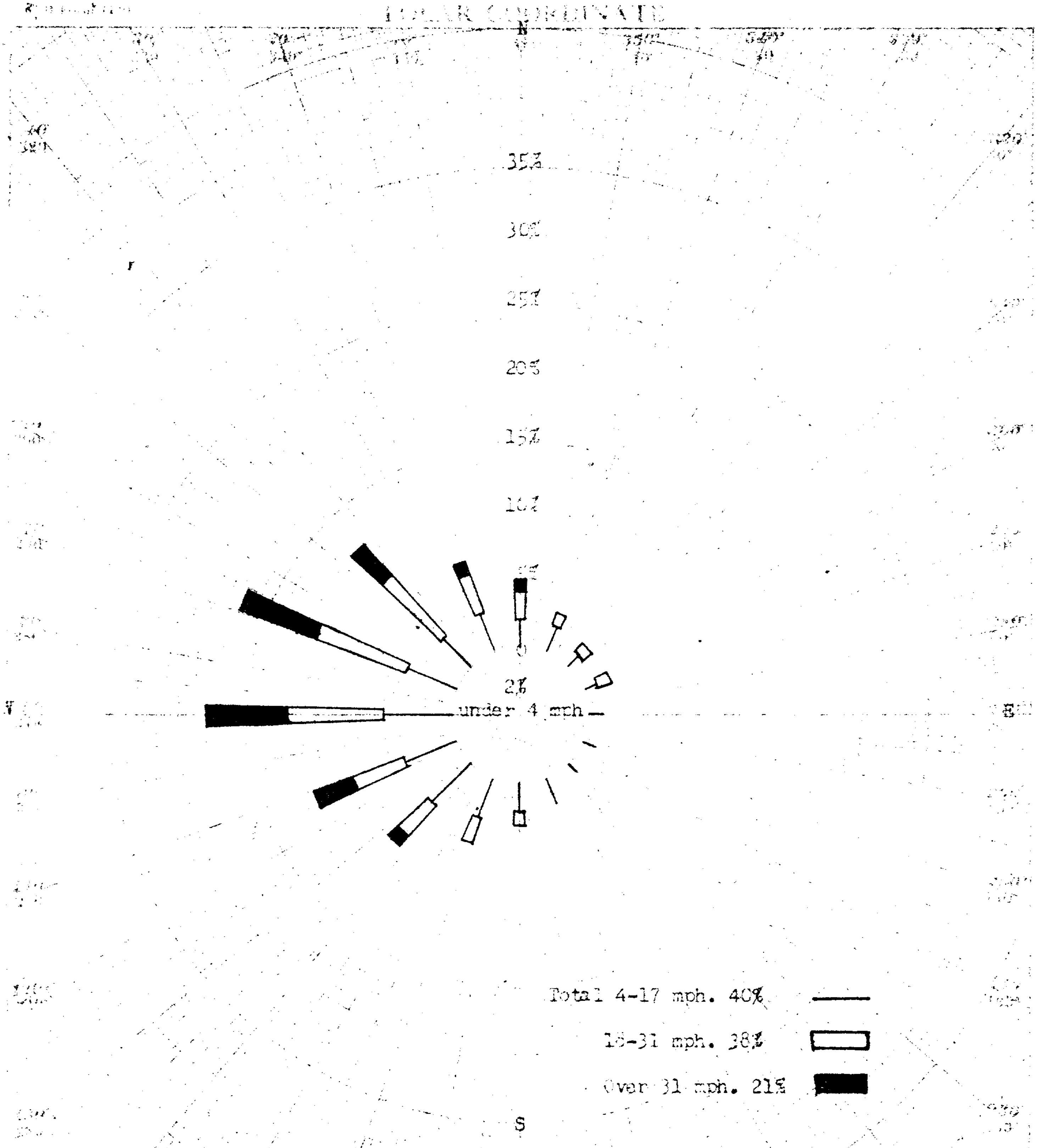
1944-1950

Annual Wind Rose



Knoxville, Tenn.

Wind Rose 2000 Ft. above the Ground



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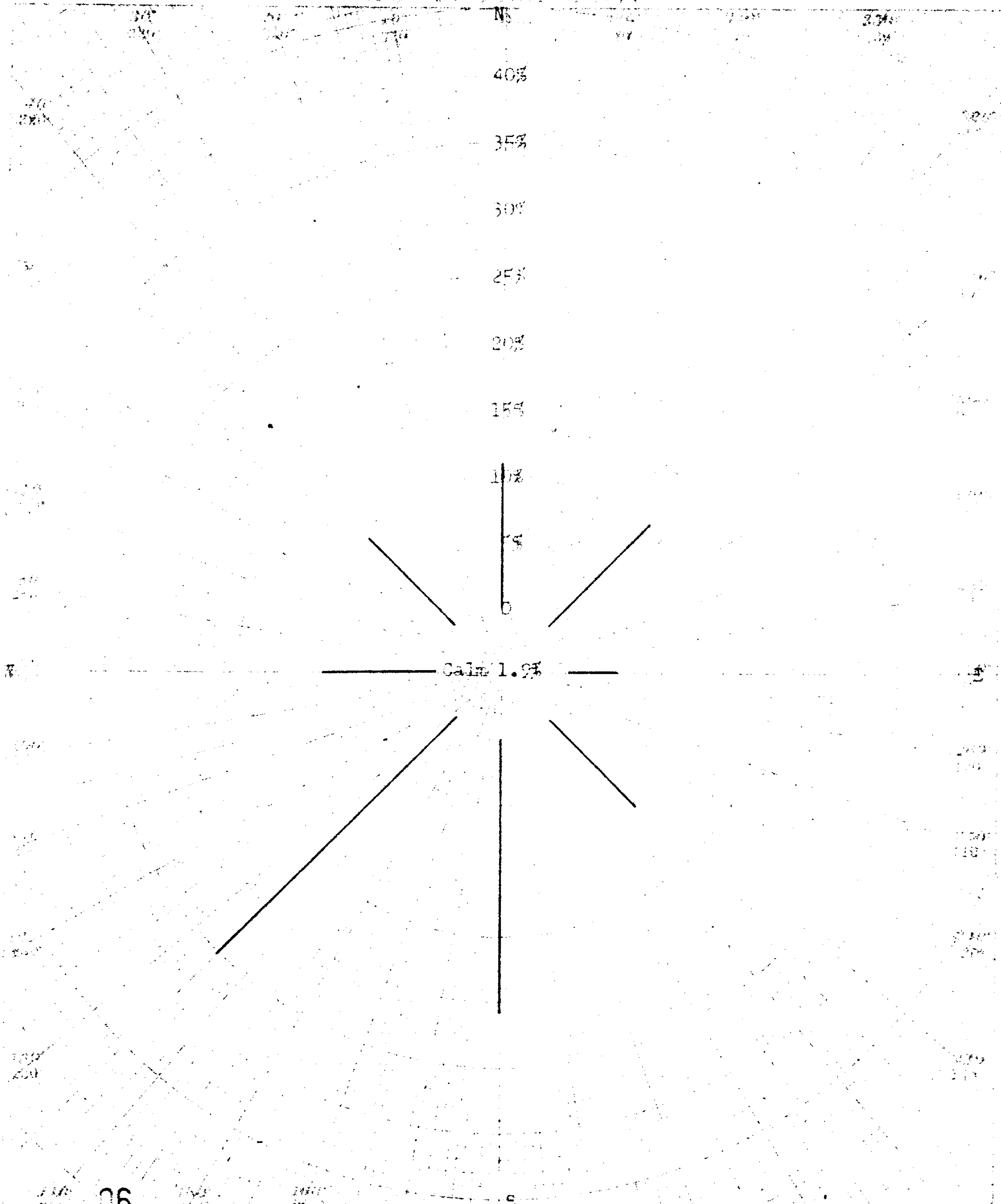
Knoxville, Tenn.

Wind Rose 10,000 ft. above ground

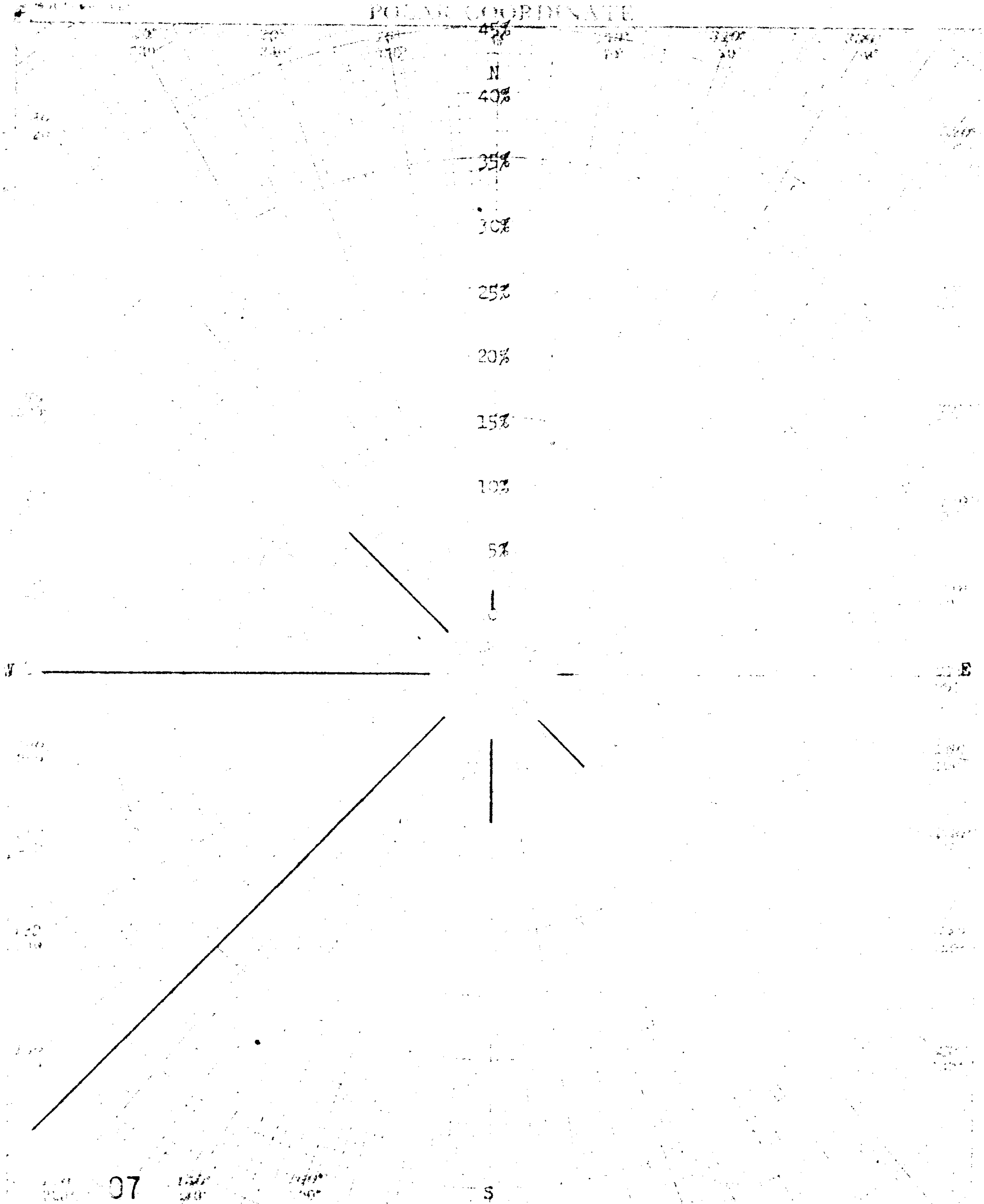


06

Knoxville, Tenn.

Aug. 1948-Feb. 1950

Wind Rose for Gradient Wind with rain.



Knoxville, Tenn.

Aug. 1948-Feb. 1950

Wind Rose for 10000 Ft. with rain